REMARKS

Applicants respectfully submit that typographical errors are corrected by this amendment and that no new matter has been added by this amendment. Applicants request consideration of the subject application as amended herein. The Examiner is invited to telephone the undersigned to help expedite any further prosecution of the present application.

The Commissioner is hereby authorized to credit any overpayment or to charge any fees or fee deficiencies under 37 C.F.R. §§ 1.16 and 1.17 in connection with this communication to our Deposit Account No. 02-2666.

Respectfully submitted,

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MARKED-UP VERSION SHOWING CHANGES MADE

IN THE SPECIFICATION:

Paragraph **[0001]** beginning on page 2, has been amended as follows:

[0001] This is a continuation of U.S. Provisional Patent Application Number 60/258,765, entitled "Method and Apparatus for Variable Rate Pipes" filed on December 30, 2000. The specification shares some text with patent application Serial No. 09/887,957,entitled "Method and Apparatus for a Hybrid Variable Rate Pipe," filed June 22, 2001; application Serial No. 09/887,303, entitled "Protection Mechanism for Optical Network," filed June 22, 2001; and application Serial No. 09/887,302, entitled "Method and Apparatus for a Non-BLSR Protected Layer 2/3 Channel," filed June 22, 2001.

Paragraphs **[0005]** to **[00010]** beginning on page 2, have been amended as follows:

[0005] Figures 1[a]A-1[e]E are diagrams illustrating an example of traffic flow in a Bi-Directional Line Switched Ring (BLSR) while there is and is not a failure in the ring. Figure 1[a]A (Prior Art) is a diagram of exemplary traffic flow on the ring while there is not a failure. Although a BLSR has a working channel and a protection channel for traffic flowing East and West, only one working channel and its protection channel (which traverses the ring in the opposite direction) are shown in Figures 1[a]A and 1[b]B. In Figure 1[a]A, [A]a stream of traffic 113 is received from a source external to the ring at node 101. Node 101 transmits this traffic 113 over its East span 115 on a working channel 119 to a node 103. Node 103 transmits the traffic 113 over its East span 117 in a working channel 121 to node 105. The stream of TDM traffic 113 exits the ring at node 105 to a destination external to the ring. Although extra traffic may be flowing in the protection channels of the ring, only the stream of TDM traffic 113 is shown for simplicity.

[0006] Figure 1[b]B (Prior Art) is a diagram of exemplary traffic flow on the ring while there is a failure. In Figure 1[b]B, the node 103's East span 117 has failed (e.g. severed lines). The stream of TDM traffic 113 is protection switched at node 103. Node 103 informs the other nodes in the ring of the failure. The stream of TDM traffic 113 is transmitted back to node 101 from node 103 in the protection channel 110 of node 103's West span 115. The stream of TDM traffic 113 continues around the ring to node 105 along a protection path. The protection path includes the

protection channels 114, 120, 128, and 120 carrying traffic between nodes 101 and 107, 107 and 109, 109 and 111, and 111 and 105, respectively.

[0007] Figure 1[c]C (Prior Art) is a diagram of exemplary traffic flow on the ring while there is not a failure. In Figure 1[c]C, transmit working and protection channels 137, 110 and [receiving]receive working and protection channels 119, 139 of node 103's West span 115 are shown. Similarly, transmit working and protection channels 121, 135 and [receiving]receive working and protection channels 141, 143 of node 103's East span 117 are shown. The transmit working channel 137 and the [receiving]receive protection channel 139 of node 103's West span 115 are not shown in Figures 1[a]A and 1[b]B for simplicity. The transmit protection channel 135 and the receiving working channel 141 of node 103's East span 117 are also not shown in Figures 1[a]A and 1[b]B for simplicity. A stream of working TDM traffic 104 is transmitted in the transmit working channel 137 from node 103 to node 101. Another stream of working TDM traffic 113 is received in the [receiving]receive working channel 119 and transmitted to node 105 in the transmit working channel 121 while there is not a failure. The receive working channel 141 carries TDM traffic not shown in the figure.

[0008] Figure 1[d]D (Prior Art) is a diagram of exemplary traffic flow on the ring while there is a failure. In Figure 1[d]D, the stream of working TDM traffic 104 continues to be transmitted in the transmit working channel 137. The stream of TDM traffic 113 is protection switched to the transmit protection channel 110 while there is a failure.

[0009] The ring described in Figures 1[a]A-1[d]D can be a 2 fiber or 4 fiber BLSR. The channels described in Figures 1[a]A-1[d]D are logical channels which may reside on different optical fibers depending on the ring architecture. A ring switch, which is a protection switch that occurs in both 2 fiber and 4 fiber BLSRs, is illustrated in Figures 1[c]C-1[d]D.

[00010] Figure 1[e]E (Prior Art) is a diagram illustrating a span switch while the transmit working channel 121 of Figures 1[c]C-1[d]D fails. In Figure 1[e]E, the transmit working channel 121 of node 103 fails. In a 4 fiber optical ring, the failure is detected and the stream of TDM traffic 113 is span switched to the transmit protection channel 135. A span switch is a protection switch which occurs in a 4 fiber BLSR. Physically, the East span 117 is 2 fibers. The transmit working channel 121 exists on one fiber and the transmit protection channel 135 exists on a separate fiber. The failure of the working channel 121 is a failure of the first fiber. The stream of TDM traffic 113 is switched from being transmitted over the first fiber to being transmitted over the second fiber.

Paragraphs **[00012]** to **[00013]** beginning on page 4, have been amended as follows:

[00012] Figures 2[a]<u>A</u> and 2[b]<u>B</u> are diagrams illustrating the use of a protection channel to carry extra time division multiplexed (TDM) traffic while there is and is not a failure[ ]. Figure 2[a]<u>A (Prior Art)</u> is a diagram illustrating the use of a protection channel to carry extra TDM traffic while there is not a failure. In Figure 2[a]<u>A</u>, a West span 201 is divided into a working channel 205 and a protection channel 207. The working channel 205 carries TDM traffic 209 and the protection channel 207 carries extra TDM traffic 211. An East span 203 is also divided into a working channel 204 and a protection channel 206. The working channel 204 of the East span 203 carries TDM traffic 213 and the protection channel 206 carries extra TDM traffic 215.

[00013] Figure 2[b]<u>B (Prior Art)</u> illustrates preemption of extra TDM traffic while there is a failure. In Figure 2[b]<u>B</u>, the East span 203 has failed. The working TDM traffic 213 is protection switched into the protection channel 207 of the West span 201. The protection switched working TDM traffic 213 preempts the extra TDM traffic 211 which was previously carried in the protection channel 207 of the West span 201. The extra TDM traffic 215 previously transmitted over the protection channel 207 of the East span 203 is not protected and is therefore completely lost upon the failure. The extra TDM traffic is problematic to sell to customers because it is preemptable and unprotected. A consumer could purchase the extra traffic service from two network owners or providers and alternate between the two upon failures. While the above is true for a 2 fiber BLSR, the impact to extra TDM traffic in a 4 fiber BLSR depends on the type of failure. In particular, while a ring switch in 4 fiber BLSR operates in a similar manner as described above, a span switch in a 4 fiber BLSR does not impact the extra TDM traffic transmitted on the non-failing spans.

Paragraphs **[00018]** to **[00024]** beginning on page 6, have been amended as follows:

[00018] Figure 1[a]<u>A (Prior Art)</u> is a diagram of exemplary traffic flow on the ring while there is not a failure.

[00019] Figure 1[b]<u>B (Prior Art)</u> is a diagram of exemplary traffic flow on the ring while there is a failure.

[00020] Figure 1[c]<u>C (Prior Art)</u> is a diagram of exemplary traffic flow on the ring while there is not a failure.

[00021] Figure 1[d]D (Prior Art) is a diagram of exemplary traffic flow on the ring while there is a failure.

[00022] Figure 1[e]E (Prior Art) is a diagram illustrating a span switch while the transmit working channel 121 of Figures 1[c]C-1[d]D fails.

[00023] Figure 2[a]A (Prior Art) is a diagram illustrating the use of a protection channel to carry extra TDM traffic while there is not a failure.

[00024] Figure 2[b]B (Prior Art) illustrates preemption of extra TDM traffic while there is a failure.

Paragraphs **[00026]** to **[00028]** beginning on page 6, have been amended as follows:

[00026] Figure 4[a]A is a diagram illustrating an example traffic flow while there is not a failure in an optical span according to one embodiment of the invention.

[00027] Figure 4[b]B is a diagram illustrating an example traffic flow while there is a failure in an optical span according to one embodiment of the invention.

[00028] Figure 4[c]C is a diagram of the example traffic flow 419 of Figures 4[a]A and 4[b]B while there is not and is a failure of the span 403 of Figures 4[a]A an 4[b]B in a ring according to one embodiment of the invention.

Paragraph **[00037]** beginning on page 7, has been amended as follows:

[00037] A method and apparatus is described that provides a pipe through an optical ring network that includes some bandwidth from the working and protection channels while there is no failure, but that is not completely lost on a failure. In this ring network, network elements are used that can transmit and receive TDM ring traffic. In addition, at least certain of the network elements provide two different switching techniques - TDM and packet. The packet switching provided can support any number of protocols including layer 2 and layer 3 type protocols such as ATM, Ethernet, Frame Relay, IP, etc. In addition to typical operations of [a] TDM network elements, the network elements are implemented to be able to: 1) programmably select on an STS basis certain of the incoming TDM traffic to be extracted and packet switched rather than TDM switched; and/or 2) receive packet traffic in another form and to be packet switched. Regardless of which switching

technique is used, the switched traffic going back onto the ring is put in TDM format and transmitted out. However, each time traffic is packet switched, that traffic can be statistically multiplexed (e.g., the packets can be selectively dropped based on various criteria). An exemplary implementation of such hybrid network elements is provided in Figure 5.

Paragraphs **[00039]** to **[00048]** beginning on page 8, have been amended as follows:

[00039] Figures 4[a]<u>A</u>-4[c]<u>C</u> are diagrams illustrating example traffic flow while there is and is not a failure on an optical span according to one embodiment of the invention. Figure 4[a]<u>A</u> is a diagram illustrating an example traffic flow while there is not a failure in an optical span according to one embodiment of the invention. In Figure 4[a]<u>A</u>, a West transmit span 401 is divided into a working channel 405 and a protection channel 407. In Figure 4[a]<u>A</u>, the West transmit span 401 carries two streams of traffic. In a working TDM pipe 402 the West transmit span 401 carries a stream of TDM traffic 409. The West transmit span 401 carries another stream of TDM traffic 411 having layer 2/3 traffic as payload in a layer 2/3 pipe 412. The stream of TDM traffic 411 is represented by two lines to show the layer 2/3 pipe 412 encompassing a segment of the working channel 405 and all of the protection channel 407 (it should be noted that the layer 2/3 pipe need not encompass all of the protection channel 407 – some of this channel could go unused and/or some of this channel could be used for a different purpose, e.g., extra traffic).

[00040] In Figure 4[a]<u>A</u>, an East transmit span 403 is also divided into a working channel 406 and a protection channel 408. The East transmit span 403 carries two streams of traffic. In a working TDM pipe 404 the East transmit span 403 carries a stream of TDM traffic 417. The East transmit span 403 carries another stream of TDM traffic 419 having layer 2/3 traffic as payload in a layer 2/3 pipe 414. The stream of TDM traffic 419 is represented by two lines to show the layer 2/3 pipe 414 encompassing a segment of the working channel 406 and all of the protection channel 408 (again, it should be noted that the layer 2/3 pipe need not encompass all of the protection channel 407).

[00041] The streams of TDM traffic 411 and 419 carry data traffic formatted according to a layer 2/3 protocol such as ATM, Ethernet, Frame Relay, Internet Protocol, etc.<u>,</u> as payload. The streams of TDM traffic 411 and 419 can be transmitted in a number of scenarios. The streams of TDM traffic 411 and 419 may be switched into the ring through the packet switching mechanism in

one node and exit the ring as TDM traffic from another node. The streams of TDM traffic 411 and 419 may be switched into the ring as layer 2/3 traffic through the packet switching mechanism in one node and exit the ring through the packet switching mechanism in another node in the form of layer 2/3 traffic. These examples are described as illustrations to aid in understanding the invention and not meant to be limiting upon the invention.

[00042] Figure 4[b]B is a diagram illustrating an example traffic flow while there is a failure in an optical span according to one embodiment of the invention. In Figure 4[b]B, the East transmit span 403 fails (e.g. a severed line, failing hardware, etc.). The West transmit span 401 continues to carry the stream of TDM traffic 409 in the working TDM pipe 402. The West transmit span 401 also continues to carry the stream of TDM traffic 411 having layer 2/3 traffic as payload, but only in a working layer 2/3 subpipe 433. A protecting layer 2/3 subpipe 435 now carries the stream of TDM traffic 419 having layer 2/3 traffic as payload because all traffic traveling in the working channel 406 of the East transmit span 403 prior to the failure was protection switched to the protection channel 407 of the West transmit span 401. The East stream of TDM traffic 417 now travels in the protecting TDM pipe 410 of the West transmit span 401. The West protecting TDM pipe 410 is the same size or number of timeslots as the working TDM pipe 404.

[00043] As shown in the illustration of Figures 4[a]A and 4[b]B, the streams of TDM traffic 409 and 417 are transmitted at a constant rate because they utilize the same amount of bandwidth while there is not and is a failure. In contrast, the streams of TDM traffic 411 and 419 are transmitted at a variable rate. While a failure does not exist, both streams of TDM traffic 411 and 419 are transmitted over the layer 2/3 pipe which is allocated a large segment of bandwidth including some of the working channel and all of the protection channel timeslots. While a failure exists, the streams of variable rate TDM traffic 411 and 419 are transmitted over layer 2/3 subpipes which are allocated an equal amount of the timeslots not used by the constant rate TDM traffic 409 and 417.

[00044] The variability in the pipe size is possible because of the statistical multiplexing capability of the packet switching mechanism in the network elements of the ring. Specifically, the reduction in the amount of available bandwidth for the TDM traffic having layer 2/3 traffic as payload requires the packet switch of the network element to buffer and/or to drop layer 2/3 traffic to make sure that traffic fits the provided pipe.

[00045] Figure 4[c]C is a diagram of the example traffic flow 419 of Figures 4[a]A and 4[b]B while there is not and is a failure of the span 403 of Figures 4[a]A an 4[b]B in a ring according

to one embodiment of the invention. In Figure 4[c]C, three nodes 431, 439, and 441 connect to each other to form an optical ring. Each node in a ring has a West and East transmit span, but in Figure 4[c]C only the East and West transmit spans from the node 431 and an East transmit span from the node 439 are shown. The West transmit span 401 carries traffic from node 431 to node 439. The East transmit span 403 carries traffic from the node 431 to the node 441. The East transmit span 440 carries traffic from the node 439 to the node 441. As previously shown in Figure 4[a]A, the variable rate TDM traffic 419 travels over the layer 2/3 subpipe 414 to node 441. Once node 431's East transmit span 403 fails, the variable rate TDM traffic 419 travels over the protecting layer 2/3 subpipe 435. Since the variable rate TDM traffic 419 is destined for node 441, the variable rate TDM traffic 419 is switched through node 439 and travels along node 439's East transmit span 440 in its protecting layer 2/3 subpipe 443. Node 439 knows to transmit the variable rate TDM traffic 419 onto a protecting layer 2/3 subpipe because node 431 has communicated to node 439 a protection switch.

[00046] As an illustration of the protection switch in relation to end users, assume that traffic from a first, second, and third user enter the ring illustrated in Figure 4[c]C at node 431. Also assume that the first and second user's traffic is to be terminated at node 441 and exit the ring at node 441 to an external network element. The third user is to be terminated at node 439 and exit the ring to an external network element. The traffic from all three users is transmitted over the layer 2/3 pipe from node 431 to node 441. The traffic from the third user is switched through the packet mesh of node 441 and transmitted over a second layer 2/3 pipe (not shown) between node 441 and node 439. As before, assume that there is a failure of span 403. While there is this failure, the traffic in the layer 2/3 pipe 414 is switched to the protecting layer 2/3 pipe 435. The traffic from all three users is passed through the cross connect of node 439 and terminated at node 441. The traffic from the first and second users exit the ring at node 441 while the traffic from the third user is switched through the packet mesh of node 441 and transmitted back to node 439 over the working subpipe of the second layer 2/3 pipe (not shown).

[00047] As illustrated in Figure 4[c]C, a failure on the ring does not cause the loss of the traffic on the layer 2/3 pipe, just a reduction in the available bandwidth. This is because the layer 2/3 pipe is made partially from the working channel and partially from the protection channel. As such, this layer 2/3 pipe is more sellable to customers than the extra traffic described in the background section because a failure does not result in a total loss of service. Moreover, using the BLSR

protection scheme enables the traffic traveling in the layer 2/3 pipe to be protection switched in a 50 millisecond time frame.

[00048] To provide an example of the manner in which the layer 2/3 pipe could be sold, assume that the working and protection channel parts of the layer 2/3 pipe 414 are respectively 30 mbps and 90 mbps. Assume, that each of the first, second and third users above want an equal amount of bandwidth of the layer 2/3 pipe 414. Each customer could be offered a guaranteed (in the event of a single failure) 10 mbps and a maximum of 40 mbps. The customers traffic at node 431 would be statistically multiplexed to fit the size of the layer 2/3 pipe currently being provided. The guaranteed 10 mbps per customer would be provided by the working subpipe on span 403 or the protecting layer 2/3 subpipe 435. The maximum 30 mbps per customer would be provided by the protection subpipe on span 403 while there is no failure. In this manner, partially BLSR protected layer 2/3 traffic is provided around the ring.

Paragraph **[00054]** beginning on page 13, has been amended as follows:

[00054] To provide an example of the reprogramming of the network elements to handle a ring switch, assume that the ring of Figure 4[c]<u>C</u> is a 2 fiber OC-12 BLSR (that is, 6 STSs for working and 6 STSs for protection in each direction). Also assume that each of the nodes of Figure 4[c]<u>C</u> is implemented as the network element illustrated in Figure 5; that the PCC 501 of a given node is connected through fiber to the PCC 503 of the adjacent node; that the fibers 515 and 506 are the transmit fibers; that the PCC 503 of node 431 is connected through fiber to PCC 501 of node 441; and that the fibers 517 and 508 are the receive fibers. Table 1 below illustrates the concatenations and the redirection of STSs programmed in the TPCs 519 and 525 of each node while there is not and is a failure on span 403.

Paragraphs **[00055]** to **[00058]** beginning on page 15, have been amended as follows:

[00055] In addition to the reprogramming of the TPCs, the cross connect tables and the logical interfaces are altered accordingly. As in the example described above, traffic for three users enter the ring at node 431 of Figure 4[c]<u>C</u>. To extend this example, assume that the traffic from these three users is [switching]<u>switched</u> into the ring in node 431 from the PCC 507 through the packet mesh 550, that the traffic from the first and second user is exiting the ring at node 441

through PCC 505 after being switched through the packet mesh 550, and that the traffic from the third user is exiting the ring at node 439 through PCC 505 after being switched through the packet mesh 550. While there is not a failure, the traffic from all three users is transmitted from the IL2/3PC 533 across the packet mesh 550 to the EL2/3PC 529 according to the forwarding tables, which refer to logical interfaces, and transmitted in the layer 2/3 pipe by TPC 525. While there is a failure of the fibers connecting into 431's PCC 503, the logical interfaces are modified so that the traffic from the three users is switched through the packet mesh from IL2/3PC 533 to the EL2/3PC 523 and transmitted in the protecting layer 2/3 pipe to node 439 by the TPC 519 which has been reprogrammed as described above.

[00056] In node 439, while there is not a failure, the traffic from the third user is received at the IL2/3PC 521 and switched through the packet mesh 550 to EL2/3PC 541. While there is a failure, the node 439 is modified so that the traffic for the three users received from node 431 on node 439's PCC 503 in the protecting layer 2/3 channel is switched to the protecting layer 2/3 channel to node 441. This switch will go through the cross connect, and is in fact a BLSR pass-through. An additional change for the dropping of the third users traffic is in the next paragraph.

[00057] In node 441, while there is not a failure, the traffic from all three users is received at the IL2/3PC 521 and switched through the packet mesh 550: the first and second users' traffic is switched to EL2/3PC 541, while the third user's traffic is switched to EL2/3PC 529. While there is a failure between two adjacent nodes, the logical interfaces are modified because of the failure so that the traffic for the first and second users received from node 439 on node 441's PCC 503 is switched through the packet mesh 550 from the IL2/3PC 527 to the EL2/3PC 541 and transmitted out of the ring through the PCC 505. The traffic for the third user is switched through the packet mesh from the IL2/3PC 527 to the EL2/3PC 529 and transmitted out the PCC 503 on the working layer 2/3 channel to node 439 by the TPC 525. The traffic from the third user is received at node 439 at the PCC 501 on the working layer 2/3 channel and switched through the packet mesh 550 from the IL2/3PC 521 to the EL2/3PC 541 in accordance with the forwarding tables and transmitted out of the ring by the PCC 505.

[00058] To provide another example of the reprogramming of the TPCs to handle a protection switch, assume that the ring of Figure 4[c]C is a 4 fiber OC-48 BLSR . In a 4 fiber implementation of the invention, a load balancing mechanism would be implemented to balance traffic between the working layer 2/3 channel and the protecting layer 2/3 channel (e.g., multi-link

PPP, ATM SAR, etc.). Also assume that each of the nodes of Figure 4[c]C is implemented as the network element illustrated in Figure 5; that the PCCs 501 and 507 are the transmit and receive pair respectively for the East span; and that the PCCs 503 and 505 are the transmit and receive pair respectively for the West span. Thus, while there is a failure requiring a ring switch on the East span of a node: 1) traffic coming in PCC 505 is protection switched to PCC 503; and 2) the redirect/concatenations of the TPCs 519 and 531 must be altered. Whereas while there is a failure requiring a ring switch on the West span of a node: 1) traffic coming in PCC 507 is protection switched to PCC [S]501; and 2) the redirect/concatenations of the TPCs 525 and 537 must be altered. In addition, while there is a failure requiring a ring switch on a midspan node, the redirect/concatenations of the TPCs 531 and 537 must be altered accordingly. The redirect/concatenations of the TCPs 519 and 525 are not affected because of the assumption that TPCs 519 and 525 correspond to working channels.

Paragraph **[00072]** beginning on page 22, has been amended as follows:

[00072] Figures 8A-8B illustrate example provisioning of varying size pipes around a BLSR and changing concatenations according to one embodiment of the invention. To illustrate this example of varying pipe [sized]sizes and changing concatenations in the network elements to handle a ring switch, assume that the ring of Figures [7]8A-[7C]8B is a 2 fiber OC-12 BLSR (6 STSs for working and 6 STSs for protecting in each direction). Also assume that each of the nodes of Figures [7]8A-[7C]8B is implemented as the network element illustrated in Figure 5. Figure 8A illustrates varying concatenations over the BLSR of Figures [7]8A-[7C]8B while there is not a failure according to one embodiment of the invention. In Figure 8A, the BLSR of Figures [7]8A-[7C]8B has varying pipe sizes on each link. Each link is labeled with one of the letters A-C to identify the type of concatenation. Table 1 identifies the concatenations corresponding to each letter (concatenations in this example conform to current standards). In this example, the entire protecting channel is used for layer 2/3 traffic while there is not a failure. Hence, only the concatenations of the working channel traffic need be identified because all traffic in the protecting channel is concatenated as STS-6c in this example. In alternative embodiments, part of the protecting channel can be used for other types of traffic. Optically switched traffic transmitted in the working channel is denoted as Wt. Layer 2/3 traffic transmitted in the working channel is denoted as Wp.